

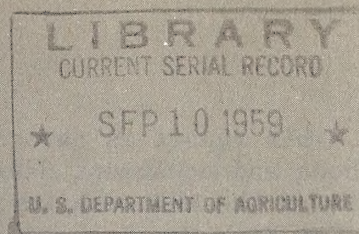
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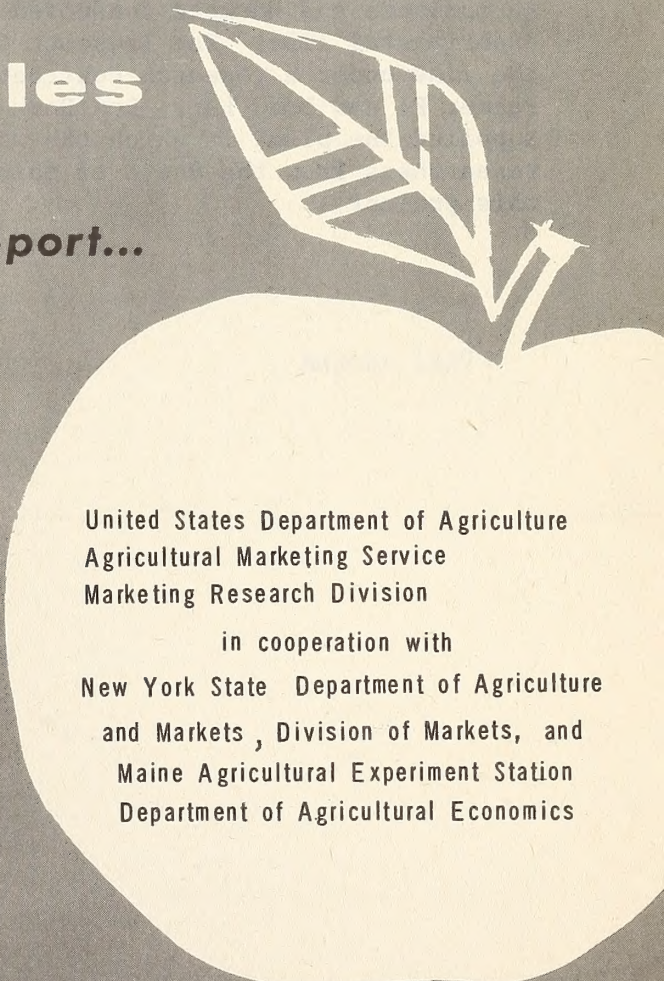


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# **AN EXPERIMENTAL PACKING LINE FOR McIntosh Apples**

*an interim report...*



United States Department of Agriculture  
Agricultural Marketing Service  
Marketing Research Division

in cooperation with  
New York State Department of Agriculture  
and Markets, Division of Markets, and  
Maine Agricultural Experiment Station  
Department of Agricultural Economics

AMS NO. 330  
Washington, D. C.



## PREFACE

This report is part of a research project to determine how apple packing methods and equipment developed for other varieties can be adapted to requirements of the McIntosh variety. This work is designed to permit packers in the New York-New England area to share in the benefits of research and development work already completed in other areas. Where these methods and equipment items prove unsatisfactory for the requirements of the McIntosh variety, new methods and equipment will be designed, developed, and tested.

As a part of this overall project, an experimental line was assembled and installed in a commercial apple packinghouse. This line incorporates the latest developments in apple packing equipment, and will serve as a basis for further developmental work.

The work was performed under the general supervision of Joseph F. Herrick, Jr., Agricultural Economist, Transportation and Facilities Branch, Marketing Research Division, Agricultural Marketing Service, U. S. Department of Agriculture, and John L. Matheson, Farm Products Promotion Coordinator, Division of Markets, State of New York Department of Agriculture and Markets. Many helpful suggestions were received from Frederick C. Winter, professor of Industrial Engineering, Columbia University, and consultant to the Transportation and Facilities Branch.

Glen A. Robinson, Division of Markets, New York State Department of Agriculture and Markets conducted the bruising and sizing tests on the experimental line. The Trescott Company, Inc., Fairport, N. Y., installed the line under a research contract with the U. S. Department of Agriculture. Palmer F. and Budd Hart, Red Hook Cold Storage Company, Red Hook, N. Y., supplied the plant in which the work was done. Many packers and agricultural researchers from the State of Maine contributed to the early planning of this project.

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## SUMMARY

An experimental packing line for McIntosh variety apples was developed by combining improved work methods and the latest commercially available equipment. These improvements enabled the McIntosh apples to be packed mechanically at a lower labor cost with no increase in injury to the fruit or in the number of off-grade apples in the packed fruit.

The labor cost, at \$1.25 per hour, for performing all packing operations at a plant handling 50,000 boxes per year, dumped at a rate of 900 boxes per day, was 14.4 cents per dumped box. Equipment cost 7.9 cents per dumped box. By increasing the volume to 150,000 boxes per year with 1,200 boxes dumped per day, these costs could be reduced to 11.7 cents per dumped box for labor, and 3.6 cents for equipment.

Each test lot of bruise-free apples was tested with a Magness-Taylor pressure tester. This device measured the resistance of the apple flesh to a plunger. The lower the resistance recorded on the pressure scale, measured in pounds of pressure required to force the plunger into the apple, the more susceptible the fruit was to bruising.

Fruit testing only 9 pounds on the firmness scale suffered 21.6 percent bruising after traveling over the complete line, fruit at 12 pounds showed 4.5 percent bruising, and fruit at 17 pounds only 1.4 percent bruising. Fruit testing 9.5 pounds was used to test the automatic box filler, and bruising amounted to 6.4 percent. When fruit testing 16 pounds was used in this test, bruising was reduced to 1.9 percent.

When the sorting crew was increased from four to six, productivity of the cell packers more than doubled. With six sorters, the packers no longer had to inspect each apple before packing it, but could pick up apples with both hands and place them into the cells. This increased productivity was accomplished with no increase in the number of below-grade apples in the cell-packed cartons.

Precise sizing did not occur with the dimension sizer. Greater accuracy may be possible by closer adjustment of the equipment but these sizing errors will continue until a way is found to position apples uniformly in the cups. However, other methods of sizing that are in common use in the industry are little, if any, more accurate.



# AN EXPERIMENTAL PACKING LINE FOR McINTOSH APPLES

## An Interim Report

By Stanley W. Burt, industrial engineer  
Transportation and Facilities Branch  
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### INTRODUCTION

Packing high-quality apples has placed a burden on apple packers' methods and equipment. Many have had to abandon mechanical packing lines and resort to hand methods to obtain quality packing. Technology in apple storage, handling, and packing is changing rapidly, and the market is becoming more demanding. On top of this, many packers are facing increased production with packing facilities which are already taxed. More efficient apple packing methods and equipment are needed to meet the problems arising from these changing conditions.

About half of all apples grown in the New York-New England area are of the McIntosh variety. In some States this variety represents nearly three-quarters of the apple crop. Besides being the predominant variety produced in the eastern area, the McIntosh is also one of the most tender and easily bruised. Any packing line that meets the demanding requirements of the McIntosh variety will be suitable for use with other varieties as well.

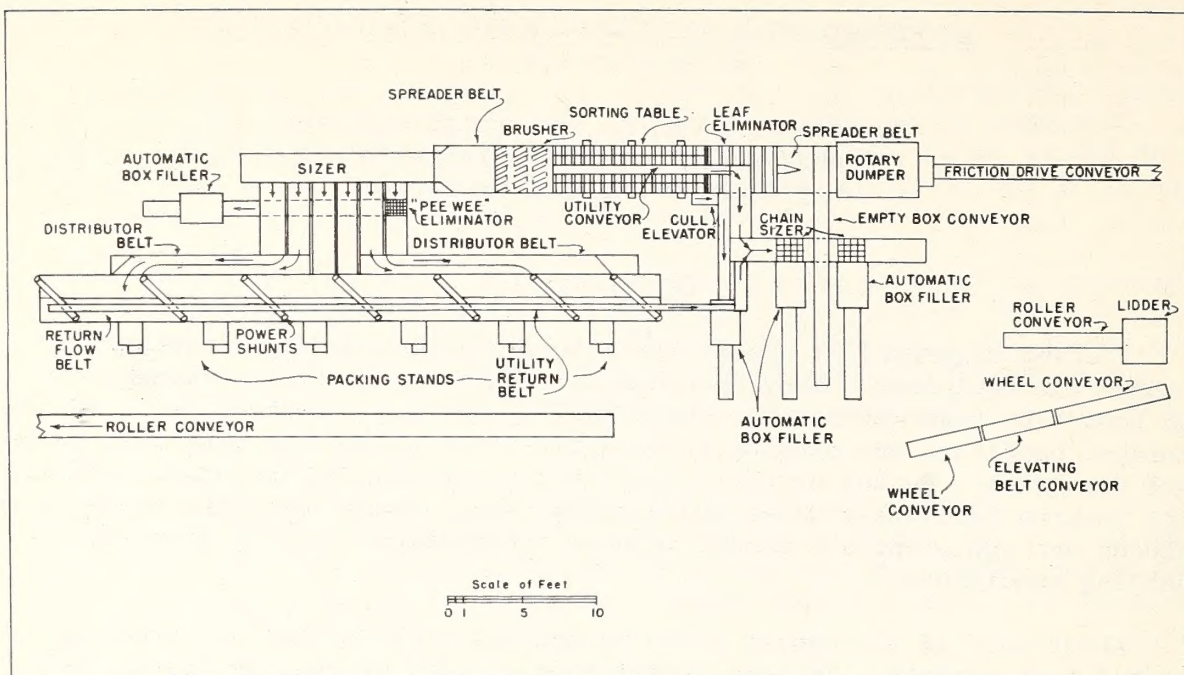
The first step in the development of a mechanical packing line suitable for McIntosh apples was to assemble a line consisting of the latest commercially available equipment and install it in the packing room of a commercial packer. This line was tested, revised, and then tested again to determine: (1) The cost of labor and equipment for packing apples, (2) the amount and severity of bruising and where it occurred, (3) effectiveness of sorting operation, and (4) accuracy of the mechanical dimension sizer.

### DESCRIPTION OF THE PACKING LINE

The experimental apple packing line consists of equipment which is commercially available. It is experimental to the extent that the combination of equipment has not been tested before with the McIntosh variety, although each item of equipment has been used successfully with other varieties and in other areas. The items were assembled into an experimental line to determine whether the advantages of mechanical packing could be applied to the McIntosh apple, and whether the equipment could be modified, if necessary, to meet the requirements of the McIntosh variety.

A layout of the complete packing line is shown in figure 1. This line consists of the following components:





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Figure 1.--Layout of experimental packing line.

Dumper.--A drum-type box dumper supplied by a 20-box capacity friction-chain conveyor (fig. 2). The box is held firmly against rubber V-belts of the dumper by two forks. As the drum turns, the box is tipped over, apples are deposited on the V-belts, and the box is lifted off the fruit by several of the belts. The apples are carried forward by the V-belts to a spreader belt. Empty boxes are carried off and fall onto a gravity conveyor on which they accumulate until removed. This dumper has an adjustable rate, with a maximum dumping capacity of 600 boxes per hour.

Leaf eliminator.--This is in common use in the Northwest, but is untested in the Northeast. This equipment is an endless series of rollers identical to those on the sorting table. These rollers, while turning, carry apples from the spreader belt to the sorting table. During this journey, leaves and other debris fall between the rollers into a collecting bin.

Sorting table.--Consists of a series of rubber-covered rollers (2-3/8" diameter and 3" on center) which travel forward and rotate at the same time (fig. 3). Each rate--translation and rotation--is independently adjustable. The sorting table receives apples from the leaf eliminator and carries them in lanes past the sorting stations. The table surface is well lighted with recessed fluorescent lights. Each sorter is provided a side chute for disposing of cull apples. All of these features were incorporated into the table design to permit a complete sorting job by the sorters so that packers would not have to reinspect the fruit. Free of the burden of reinspecting fruit, packers were able to more than double their output of packed apples.

Brusher.--This is for removing residual spray dust and polishing the fruit. It was installed for use with other varieties although it was not used with McIntosh apples.

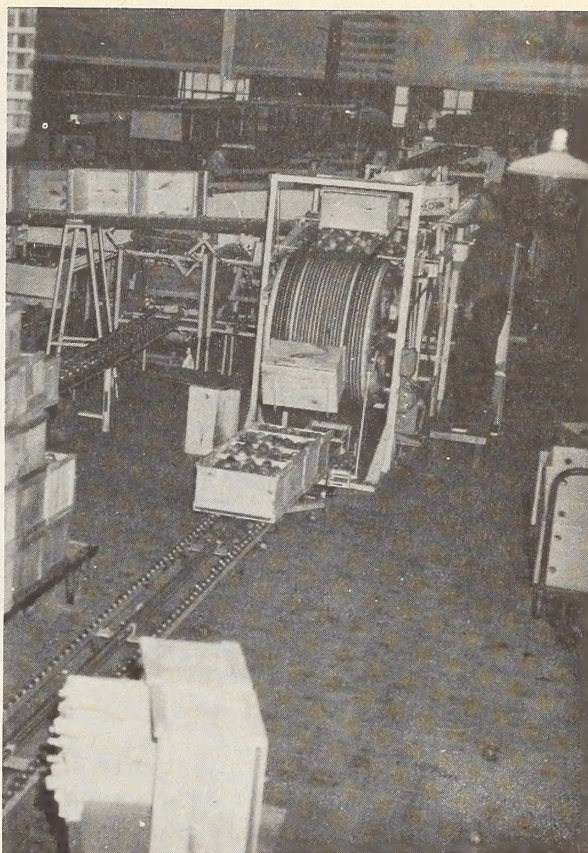


Sizer.--A high-speed dimension-type apple sizer, capable of sizing 350 crates per hour into 6 size groups (fig. 4). Dividing the cell-pack apples into 6 sizes, as opposed to only 3 or 4, gives a more uniform, more attractive, and better-protected pack which has greater appeal to both buyers and consumers.

Return-flow belt.--From the sizer, apples are delivered via take-away and distributor belts to the return-flow belt. The return-flow belt is, in fact, two adjacent belts traveling in opposite directions; it is divided into sections by powered shunts. Each section is for a particular size of apple, and serves as an accumulating system for the packer. Because each shunt is movable, it is possible to adjust the amount of belt surface allotted to each size. Apples circulate on the belts, transferring from one to the other, until they are removed by the packer.

Eliminator.--A chain-type sizer for removing small or pee-wee size fruit. This chain sizer is installed in the first take-away belt from the sizer (fig. 1). Apples under 2-1/4 inches fall through the eliminator onto a belt conveyor; the conveyor then delivers them to an automatic box filler. When the chain eliminator is made a part of this take-away belt, only a small part of the fruit must travel over it, whereas all the apples ride over the eliminator when it is located between the dumper and sorting table. In the experimental line, those apples that ride over the eliminator are all small and the least susceptible to injury.

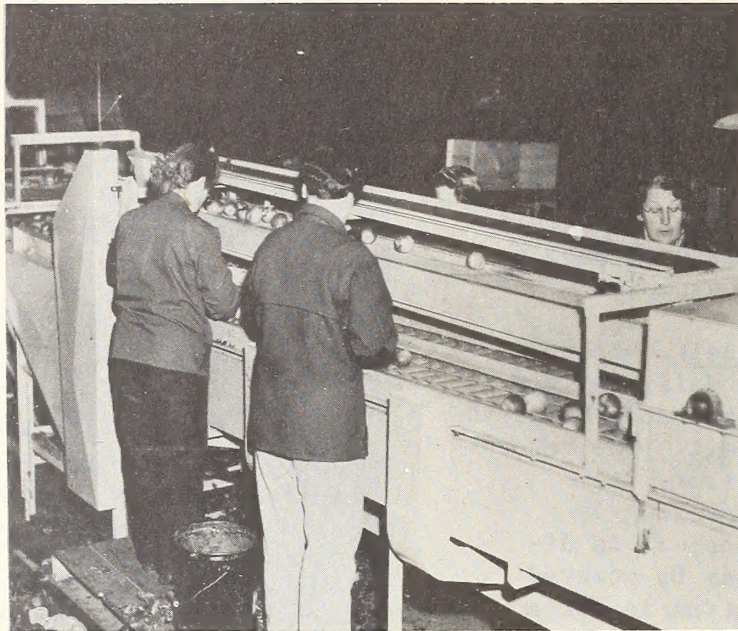
Utility belt.--For removing utility grade apples after they are taken from the sorting table (fig. 5). A 10-inch wide belt over the sorting table receives utility fruit from the sorters. This belt delivers the apples to another belt running at right angles and on a downgrade, which in turn delivers the fruit to an automatic box filler. A 4-inch belt mounted 12 inches above the return-flow belt connects with the utility belt. The cell-packer places utility-grade apples on this 4-inch belt, which returns them to the utility-grade belt.



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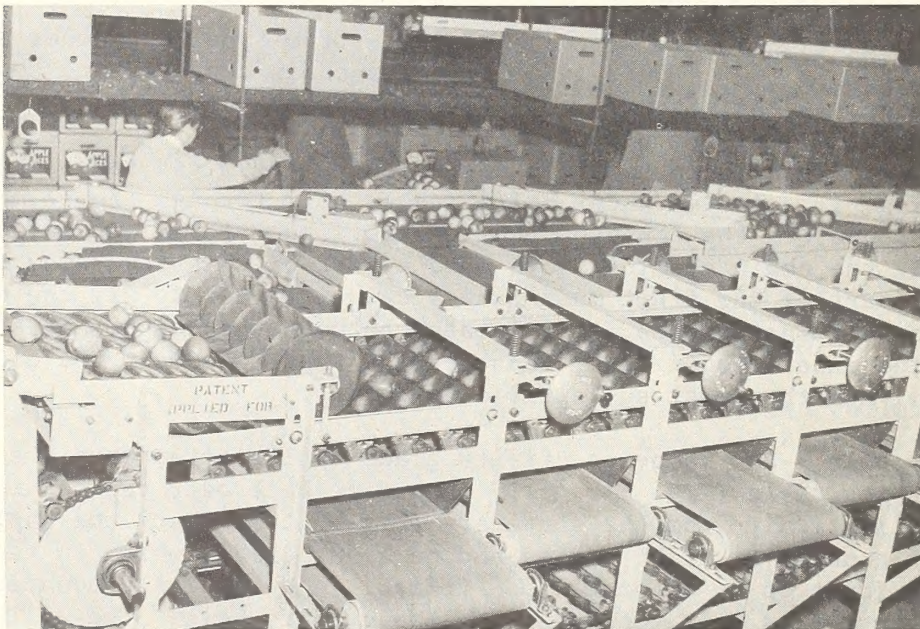
Figure 2.--Drum-type box dumper showing friction-chain conveyor and empty-box take-away conveyor.





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Figure 3.--Sorting table with 6 sorting stations (only 4 in use). Two utility-grade removal belts are over center of table, but only one in use. Note cull chutes at side of table, and lane dividers.



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Figure 4.--Dimension-type sizer. Singulator permits only one apple in a cup. As cups spread apart apples fall through onto take-away belts.



Automatic box fillers are used to jumble-fill boxes at rates up to 450 boxes per hour without the use of manual labor. The box is automatically positioned, tilted up, filled with fruit, and discharged from the box filler. The only labor required is for supplying empty boxes and removing the full ones. This equipment was used to box both cull and utility-grade apples. Figure 6 shows a box filler in use.

## COST OF PACKING WITH THE EXPERIMENTAL LINE

The evaluation of a packing line must take into consideration the cost of moving a given quantity of fruit through the dumping, sorting, sizing, and packing operations. There are other costs, such as management, supervision, heating, or housekeeping, that are at least partly chargeable to the packing operation. However, such costs vary widely between plants, and are more likely to reflect the effects of localized conditions rather than the effectiveness of the packing method and equipment. Consequently, only the costs of direct labor and equipment are included in this analysis.

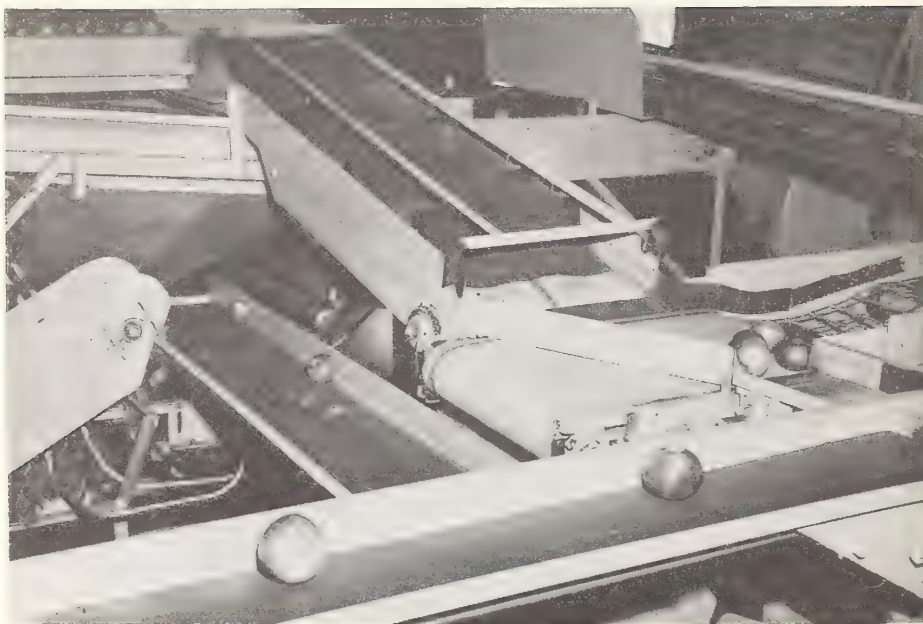
### Assumptions Used in Computing Costs

To compute packing costs, it is necessary to assume a set of conditions relating to the volume of fruit both dumped and packed, the rate at which apples are dumped, and wage rates of workers. The conditions assumed here represent those which might be found in an average-size packing plant in the New York-New England area.

These conditions will probably never occur together in a packinghouse. However, use of a reasonable set of assumptions permits individual packers to estimate what the cost of such operations would be in their own plants. The following assumptions were used in computing the cost of packing with the experimental line having a dumping rate of 50,000 boxes per year or 900 boxes per day and having a wage rate (to include overtime, bonuses, insurance, social security payments, and other fringe benefits) of \$1.25 per hour:

Weight of apples in different containers:	<u>Pounds</u>
Northeast box, orchard run . . . . .	38
Cell pack, carton. . . . .	37
Utility grade in jumble-pack . . . . .	40
Cull grade in jumble-pack. . . . .	40
Bagged apples in master carton . . . . .	38
Distribution of orchard-run apples:	<u>Percent</u>
Cell pack. . . . .	60
Utility grade (jumble-pack). . . . .	25
Cull grade (jumble-pack). . . . .	5
Bags . . . . .	10





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Figure 5.--Belt system for disposing of utility grade apples. Apples from the sorting table ride under the retarding drape; those returned by packers are on the narrow belt in foreground. Note elevating conveyor and belt (left center) for removal of culls.



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Figure 6.--Automatic box filler in position and receiving apples from the utility grade disposal belt.



Number of containers packed annually:	<u>Number</u>
Cell pack, carton . . . . .	30,810
Utility grade (jumble-pack) . . . . .	11,875
Cull grade (jumble-pack) . . . . .	2,375
Master cartons of bagged apples . . . . .	5,000

### Cost of Labor

Labor requirements for performing each of the packing operations were determined by time study. Productive effort of the workers was measured, and then adjusted to normal working levels. Also, when the skill of a worker was noticeably different from the norm for the operation he was performing, his recorded time was adjusted accordingly. To the time values so derived, an allowance for personal requirements and fatigue was added. These allowances were based on the nature of the work performed. Setting down full boxes for the dumper and tending box fillers were each given a combined allowance of 25 percent, and all other work 15 percent.

Combination U. S. Extra-Fancy and U. S. Fancy grade apples were packed in cell cartons, with only the largest sizes being tray packed. Smaller fruit was bagged, but because most of the packed apples went into cell cartons, cost figures were developed for this type of pack.

### Dumping

No physical effort was expended in removing apples from the field box and distributing them on the spreader belt--this was all done mechanically. But physical effort was still required in supplying full boxes to the drum dumper. This task, then, became the principal responsibility of the worker. When it did not occupy his time, he was free to perform other duties.

If the boxes being dumped were from controlled-atmosphere storage, the worker had to remove nailed slats from the boxes, take out cardboard covers, and place the boxes on the conveyor supplying the dumper. Removing a full box from the load and placing it down on the conveyor supplying the dumper required 0.10 man-minute per box; to remove slats and cardboard covers from each box required an additional 0.29 man-minute. At a dumping rate of 112.5 boxes per hour (900 boxes per 8-hour day), 44 minutes of each hour were devoted to removing slats and cardboard covers and placing boxes on the conveyor. This left 16 minutes, or one-fourth of the worker's time, free for performing other work.

Only 11 minutes of each hour were spent by the worker in placing full boxes on the conveyor supplying the drum dumper. When boxes without slats and cardboard covers were dumped, 49 minutes of every hour were left this worker for other work. This was sufficient time to permit him also to operate the lid nailer, bring fruit from storage, and remove loads of empty boxes from the dumper. At a rate of 900 boxes dumped per day, labor for the dumping operation totaled \$10 per day, or 1.1 cents per box.



## Sorting

Picking out of utility and cull grade apples from field-run fruit is done in the sorting operation. Sorters stand at the sorting table and watch the fruit as it rotates and moves past them. Defective apples are placed on the utility belt or in the cull chute. These workers are trained to spot defects and to distinguish grades, and their reactions become almost automatic.

Sorters work at fixed work stations, so they cannot leave to perform other work while apples are passing before them. Their ability to sort apples properly varies with the number of sorters, the dumping rate, and the percent of culls and utilities in the orchard-run fruit. How well these workers sort the apples can be measured by (1) the percent of culls and utilities left in the run-off fruit, and (2) the percent of picked-out fruit that was really U. S. Extra-Fancy or U. S. Fancy grade. The run-off fruit was cell packed and stamped a combination U. S. Extra-Fancy and U. S. Fancy grade. At a given dumping rate and with a fixed sorting crew, a change in the quality of fruit being dumped will change the number of errors made in sorting. These relationships were studied, and will be discussed later.

Sorting crews of both four and six workers were tested. At \$1.25 per hour for 8 hours, four sorters cost \$40 per day, and six sorters \$60 per day. At a dumping rate of 900 boxes per day these costs were 4.4 cents per box with four sorters and 6.7 cents per box with six.

### Packing Combination U. S. Extra Fancy and U. S. Fancy Grade Apples

To pack a cell-type carton, the packer removed an empty carton from the overhead wheel conveyor and placed it down on a packing stand. The worker placed a cardboard pad from a nearby supply in the carton, and opened a cell-former from another pile and placed it in the carton so that it rested on the cardboard pad. With this done, the packer removed apples from the return-flow belt with both hands (usually two apples per hand) and placed them in cells. Apples were packed without inspection but any obvious off-grade fruit was removed. When the cells in one layer were filled, the packer inserted another cardboard pad and cell-former, and continued packing. When the last layer was filled the carton was lifted from the packing stand and set down on the take-away conveyor.

Labor required to cell-pack one carton of size 120 apples this way was 2.75 man-minutes:

	<u>Man-minutes</u>
Position carton on stand . . . . .	0.13
Place 4 cardboard pads and cell formers. . . . .	.59
Place apples in cells . . . . .	1.94
Remove full carton . . . . .	.09
Total . . . . .	<u>2.75</u>

At \$1.25 per hour, the labor cost to pack one carton totaled 5.7 cents. If 60 percent of the fruit dumped was cell-packed into 555 cartons, the daily



cost of labor to cell-pack combination Extra Fancy and Fancy grade apples would be \$31.64. This is actually a theoretical cost since to achieve it would require a packing crew of 3.2 workers. Thus four packers must be employed, and this raises the cost to 7.2 cents per carton, or \$40 per day. Although this is more labor than is needed to cell-pack, it permits these workers also to take care of the bagging that must be done.

There is another method of cell-packing in common use. With this method, the packer removed apples from the return-flow belt with one hand, inspected them for injuries and other grade requirements and then placed them in cells. To cell-pack 1 carton of size 120 apples this way required 7 man-minutes, or 4.25 man-minutes more than when the packer did not reinspect each apple.

### Boxing Utility and Cull Grade Fruit

Apples that did not meet the quality of U. S. Extra-Fancy or U. S. Fancy grade were removed by the sorters and deposited in the cull chute. From the cull chute the apples went to a conveyor which delivered them to an automatic box filler. Utility-grade apples were placed on the utility disposal belt which delivered the utility fruit, via belt conveyors and chain sizer, to one of two automatic box fillers. At the box filler, apples were delivered into boxes until a preset weight was achieved (fig. 6). At this point, the conveyor stopped delivering apples until the filled box was ejected and another set in its place. Then the conveyor was automatically turned on and box filling resumed.

Filling boxes with cull or utility grade apples was accomplished without the benefit of direct labor. The entire operation of filling and weighing was performed automatically. However, a worker was required to supply empty boxes to the machines and to remove full boxes from the accumulator conveyors. Another worker was needed to arrange the top layer of each box of utility apples, and to add the last few apples to fill the box.

When dumping occurred at a rate of 900 boxes per day, and 30 percent of the apples dumped were cull and utility grade, a worker was busy nearly full time tending the box fillers. His responsibilities included supplying empty boxes to fillers for pee-wees, cull grades, and utility grade fruit, and removing full boxes from the box fillers. In addition, he stacked empty boxes from the dumper, cleared jammed areas wherever they occurred, and lined boxes.

When utility grade apples were boxed by automatic box filler, one or two workers topped the boxes before lidding. Normally, one worker was sufficient for this operation but when either the dumping rate was high or an unusually large percentage of apples were running to utility grade, a second worker was used.

Topping was done on a wheel conveyor at waist level. Jumble-filled boxes of utility grade fruit from the box filler were delivered to working height by an elevating belt conveyor. Here the topper leveled the box, arrayed the top apples in an orderly arrangement, added fill-in apples from a nearby box, and pushed the box forward toward the lidding machine.



On an average, topping of utility grade fruit was performed in this manner at a rate of 1.04 man-minutes per box. At this rate one topper can handle all the boxes to be topped with time to spare. Two workers--one tending the automatic box fillers, and the other topping boxes--took care of all cull and utility grade apples at a labor cost of 7.8 cents per box (258 boxes filled, at \$20 per day for 2 workers).

### Cost of Equipment

Items of equipment which make up the experimental line have already been described, and labor costs associated with this line were presented in the previous section. To the labor costs must be added those of owning and operating the packing line if a total cost picture for this equipment is to be shown.

Table 1 gives the approximate cost of owning and operating each item of equipment used in the experimental packing line illustrated in figure 1. Initial cost includes delivery to a central New England area, plus an installation cost of 5 percent of the purchase cost.

Depreciation was computed on a straightline basis--initial cost divided by the number of years of expected life. Interest on money invested was set at 5 percent of the average investment, and insurance and taxes at 4 percent of the initial cost. An electric power rate of 2.7 cents per kilowatt hour was used, with the line operating 450 hours yearly. Annual cost for maintaining the equipment was based on experience coupled with recommendations of equipment manufacturers. Breaking down cost figures in this way permits a complete analysis of ownership and operating costs for each item of equipment. The complete line, including 6 packing stands, 7 power shunts, and 4 automatic box fillers cost \$3,964.87 per year, when 50,000 boxes were dumped each year, at a rate of 900 boxes per day. At this rate, the cost of owning and operating such a line was 7.9 cents per box dumped.

This same line, with no additional equipment, has a capacity considerably greater than 50,000 boxes dumped per year, or 900 boxes per day. It could, in fact, easily handle 150,000 orchard-run boxes, at a daily dumping rate of 1,200 boxes. Using the line at this rate would increase its annual ownership and operating cost from \$3,964.87 to \$5,417.45 or 37 percent (table 2). This is because the equipment would last fewer years and more power and maintenance would be required. While the total annual equipment cost is greater for this higher volume, the unit cost is considerably less--only 3.6 cents per box dumped. This is 4.3 cents less per box than when only 50,000 boxes were dumped yearly. This comparison illustrates the importance of using equipment up to its capacity, so that its cost is spread over the greatest possible number of boxes.

### Combined Labor and Equipment Costs

The cost of labor for packing 50,000 boxes dumped annually with the experimental line was 14.4 cents for each orchard-run box dumped, and the cost



Table 1.--Ownership and operation cost for each component of the experimental packing line, based on 50,000 boxes dumped per year at a rate of 900 boxes per day

Equipment	Number of units in experimental line	Initial cost per unit	Expected life	Ownership cost				Operating cost			
				Dollars	Years	Dollars	Interest at 5 percent	Dollars	Power 3/	Dollars	Total annual cost
	Number	Dollars	Years	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Friction chain conveyor.....	1	170	12	14.17	12	3.54	6.80	24.51	5.35	2.00	7.35
Drum dumper.....	1	1,690	12	140.83	12	35.21	67.60	243.64	5.35	20.00	25.35
Empty box conveyor.....	1	95	15	6.33	15	1.58	3.80	11.71	-	2.00	2.00
Spreader belt after dumper.....	1	425	12	35.42	12	8.85	17.00	61.27	8.20	5.00	13.20
Leaf eliminator.....	1	530	12	44.17	12	11.04	21.20	76.41	2.68	5.00	7.68
Sorting table (including cull chutes and belt).....	1	2,580	12	215.00	12	53.75	103.20	371.95	5.35	30.00	35.35
Brusher.....	1	715	12	59.58	12	14.90	28.60	103.08	2.46	10.00	12.46
Spreader belt after brusher.....	1	515	12	42.92	12	10.73	20.60	74.25	8.20	5.00	13.20
24-inch dimension sizer with take-away belts.....	1	5,400	12	450.00	12	112.50	216.00	778.50	10.70	60.00	70.70
35-foot distributor belt.....	1	1,650	12	137.50	12	34.38	66.00	237.88	7.13	20.00	27.13
Chain eliminator with take-away belts.....	1	450	12	37.50	12	9.38	18.00	64.88	8.20	5.00	13.20
41-foot return-flow belt.....	1	3,340	12	278.33	12	69.58	133.60	481.51	7.13	35.00	42.13
Packing stand.....	6	45	15	19.33	15	4.83	11.60	35.76	-	-	-
Power shunt.....	7	225	12	131.25	12	32.82	63.00	227.07	16.66	20.00	36.66
Cull elevator.....	1	95	12	7.92	12	1.98	3.80	13.70	2.68	2.00	4.68
Utility grade conveyor and chain sizers.....	1	1,120	12	93.33	12	23.33	44.80	161.46	16.04	10.00	26.04
Automatic box fillers.....	4	585	12	195.00	12	48.75	93.60	337.35	17.60	100.00	117.60
Utility grade return belt.....	1	640	12	53.33	12	13.33	25.60	92.26	4.40	10.00	14.40
46-foot filled box conveyor.....	1	540	12	45.00	12	11.25	21.60	77.85	10.70	10.00	20.70
Total cost.....				2,006.91		501.73	966.40	3,475.04	138.83	351.00	489.83

1/ Includes purchase cost, transportation to Central New England area, and installation.

2/ Equal to 2.5 percent of initial cost.

3/ Based on 2.7 cents per kilowatt hour.







of equipment 7.9 cents (table 3). These costs do not include equipment and labor for bagging apples, or placing bags in master cartons. Some additional equipment cost would be associated with the bagging operation, but the present cell packers and utility-grade topper could furnish the necessary labor from time that would otherwise be idle.

Table 3.--Labor and equipment costs for performing packing operations with the experimental packing line--50,000 boxes dumped annually, at 900 boxes per day

Cost item	Crew size	Per day	Cost	
			Per box dumped	Per container
	Number	Dollars	Cents	Cents
Labor:				
Dumping . . . . .	1	10.00	1.1	1/ 1.1
Sorting . . . . .	6	60.00	6.7	1/ 6.7
Packing . . . . .	4	40.00	4.4	2/ 7.2
Boxing utilities and culls. . .	2	20.00	2.2	3/ 7.8
Total labor . . . . .	13	130.00	14.4	-
Equipment . . . . .	-	70.80	7.9	-
Total labor and equipment 4/ .	13	200.80	22.3	

1/ Based on 900 Northeast boxes dumped daily.

2/ Based on 555 cell type cartons packed daily.

3/ Based on 256 Northeast boxes filled daily.

4/ Costs for bagging apples were not developed, since no experimental equipment or methods were involved.

Thirteen workers constitute the packing crew: One dumper, 6 sorters, 4 cell packers, and 2 utility and cull grade boxers. The operation of a packinghouse requires bring-up men, labelers, tally clerks, load-out men, and others in addition to these. However, these workers were not included in this analysis, since their work was not directly associated with the experimental equipment which was being tested.

Total daily cost for packing 50,000 dumped boxes per year at 900 boxes per day was \$200.80 or 22.3 cents for each box dumped. Labor represents 65 percent, and equipment 35 percent of this cost.

The effect of an increased volume of apples dumped and packed with this equipment is illustrated in table 4. By increasing the annual volume to 150,000 boxes dumped at a daily rate of 1,200 boxes, cost per box dumped would be reduced from 22.3 cents to 15.3 cents. Since the cost of equipment is spread over more packing days, the total daily cost would be reduced from \$200.80 to \$183.32. This would be accomplished despite a \$10 increase in the daily cost of labor. These comparative figures are a clear example of gains to be realized by using equipment to its maximum capacity.

Table 4.--Labor and equipment costs for performing packing operations with the experimental packing line--150,000 boxes dumped annually, at 1,200 boxes per day

Cost item	:	:	Cost		
			Per	Per box	Per
	size	day	dumped	container	
	Number	Dollars	Cents	Cents	
Labor:					
Dumping . . . . .	1	10.00	0.8	<u>1/</u>	0.8
Sorting . . . . .	6	60.00	5.0	<u>1/</u>	5.0
Cell packing. . . . .	5	50.00	4.2	<u>2/</u>	6.8
Boxing utilities and culls. . . . .	2	20.00	1.7	<u>3/</u>	5.8
Total labor. . . . .	14	140.00	11.7		-
Equipment . . . . .		43.32	3.6		-
Total labor and equipment <u>4/</u> . . . . .	14	183.32	15.3		-

1/ Based on 1,200 Northeast boxes dumped daily.

2/ Based on 739 cell type cartons packed daily.

3/ Based on 342 Northeast boxes filled daily.

4/ Costs for bagging apples were not developed, since no experimental equipment or methods were involved.

#### BRUISING, SORTING, AND SIZING TESTS

After the line had been installed, a few weeks were allowed for the workers to become familiar with its operation. During this period adjustments and corrections were made so that each component worked properly, and the entire line was in synchronization. Then, when controlled-atmosphere rooms were opened and a good supply of fruit was assured, testing was begun. Tests were conducted over an extended period, and were designed to yield information for evaluating: (1) Amount of bruising caused by the experimental line, (2) number of apples misgraded, and (3) accuracy of the sizer.

#### Bruising Caused by the Experimental Line

Each component of the line was tested separately, and then the entire line as a unit. Only bruise-free McIntosh variety apples were used, so that the number and severity of resulting bruises could be determined. In all, nine different components were tested, utilizing nearly 5,000 bruise-free apples of varying firmness. In selecting test apples, several lots of incoming fruit were sorted through until sufficient bruise-free apples were found to permit a valid test of the component. Figure 7 shows how each apple was examined individually to assure that only bruise-free fruit was used in the bruise tests.



## Determining Firmness of Test Apples

Firmness of the test apples was determined by a Magness-Taylor pressure gauge (fig. 8). With this device, a plunger with a diameter of 7/16-inch was inserted into the flesh of an apple where the peel had first been removed. The resistance of the apple, measured in pounds, registered on a scale in the handle of the tester. The harder the fruit, the greater its resistance, and the more pounds it registered on the firmness scale. Firmness of the fruit was probably the most important single factor in determining the amount and severity of bruising that an apple incurred in the packing operation. The evidence indicates a firmness index--around 10 or 11 pounds--below which apples cannot safely be handled mechanically. In fact, it is questionable if such soft apples can be safely handled by any means.

### Criteria for Evaluating Bruise Damage

Bruises were classified as either slight, moderate, or severe. This permitted the extent of each bruise as well as the number of bruises to be tabulated. A definition of each bruise classification as used in this study appears below:

#### Slight Bruising - (Applies to U. S. Extra-Fancy Grade)

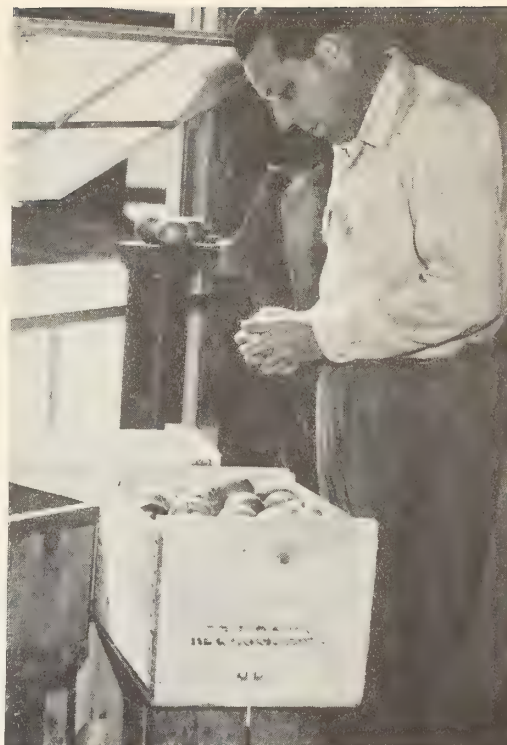
- a. Bruises of slight depth with a single bruise exceeding 1/2" in diameter or an aggregate area of bruises exceeding 3/4" in diameter.
- b. Bruises of lesser area more than slight depth or soft.

(Slight depth means not over 1/8")

#### Moderate Bruising - (Applies to U. S. Fancy and U. S. No. 1 Grades)

- a. Bruises of moderate depth with a single bruise exceeding 3/4" in diameter or an aggregate area of bruises exceeding 1" in diameter.
- b. Bruises of lesser area more than moderate depth or soft.

(Moderate depth means not over 1/4")



BN-7506

Figure 7.--Test fruit was selected by careful examination of each apple to assure that it was free of bruise.

Serious Bruising - (Applies to U. S. Utility Grade)

- a. Bruises that are more than moderate depth with a single bruise exceeding 1" in diameter or an aggregate area of bruising exceeding 1-1/4" in diameter.
- b. Bruises of lesser area that are deep or soft enough to affect the quality of the apple.

(Deep bruises mean those that are over 1/4")

Note: The terms are applied to individual specimens and based on medium size apples (125 to 160 count or 2-5/8" to 3" in diameter); greater or lesser amounts are allowed according to the sizes of the apples.



BN-7513

Figure 8.--Worker measuring firmness of an apple with a Magness-Taylor pressure tester.

In testing a component of the line, a lot of bruise-free apples was "run-through" the component in the same manner as regular fruit. Apples were set down gently at the beginning of the test, and carefully removed at



the completion. Any bruising that appeared could then be attributed to a specific component of the line.

After completing a test run, the fruit was recovered and set aside at room temperature for a period of 24 hours. When this period had elapsed each apple was examined, and the number of apples bruised, together with the severity of their bruising, was recorded. The results are summarized in table 5. In some cases, test lots comprising apples of varying degrees of firmness were used, so that the relationship between fruit firmness and amount of bruising could be determined.

### Conducting Bruise Tests

Orchard run fruit was dumped by the drum dumper, carried across the leaf eliminator, and passed over the sorting table. U. S. Fancy and better apples continued through the singulator and sizer and traveled on the return-flow belt; utilities were placed on the utility disposal belt and were collected by automatic box fillers. Each component was tested individually with bruise-free apples to determine the amount of bruising it caused, and then they were tested together as a complete line.

Dumper.--Field crates of bruise-free McIntosh apples were placed down on the friction-chain conveyor which delivered them to the drum dumper. Arms on the dumper picked up the crates and carried them through the complete dumping cycle. Each field crate was full, but no fruit extended above the top of the crate. As apples dropped from the crate they scattered onto the spreader belt, from which they were recovered and carefully placed in boxes for holding. Fruit did not go onto the eliminator.

One lot of apples tested had an average firmness of only 9-10 pounds, and 5.6 percent of them were bruised. Of these, 1.6 percent were bruised to a moderate degree, probably by an occasional top apple wedging between the crate edge and rubber V-belts; or by an apple being pressed against the V-belts as the crate was inverted. When fruit testing 16 pounds was dumped, only 0.3 percent were bruised, and then only slightly. During a day's run, overfilling of crates was probably responsible for most of the bruising that took place in the dumping operation.

Leaf eliminator.--Apples were set down on the spreader belt following the dumper and recovered at the discharge end of the eliminator. Fruit testing 15 pounds was used to test this component. Only 1 percent of these apples bruised, and then only to a slight degree.

Sorting table.--Bruise-free apples were introduced at the head of the sorting table, traveled the length of the table (14 feet), and were recovered after they left the brusher (which was not in operation), and had rolled out onto the spreader belt supplying the singulator. During the test, rollers were rotating at 94 revolutions per minute, and the rate of translation was 30 feet per minute.

Table 5.--Results of bruising tests on individual components of the experimental packing line

Equipment tested	Firmness of fruit when tested	Percentage of apples that were bruised 1/		
		Slight bruising	Moderate bruising	Total
	Pounds	Percent	Percent	Percent
Dumper:				
Lot 1 . . . . .	16.0	0.3	0	0.3
Lot 2 . . . . .	11.0	4.9	0	4.9
Lot 3 . . . . .	2/	4.0	1.6	5.6
Leaf eliminator . . . . .	15.0	1.0	0	1.0
Sorting table:				
Lot 1 . . . . .	17.0	0	0	0
Lot 2 . . . . .	14.0	.9	0	.9
Singulator and sizer. . . . .	14.5	1.0	0	1.0
Return flow belt:				
Apples on belt for 5 minutes				
at 1 r.p.m. . . . .	2/	.8	0	.8
Apples on belt for 10 minutes				
at 2 r.p.m. . . . .	10.0	3.0	0	3.0
Complete line--dumper to return- flow belt:				
Apples on return-flow belt for 2 minutes:				
Lot 1 . . . . .	17.0	1.4	0	1.4
Lot 2 . . . . .	14.5	2.3	0	2.3
Utility grade disposal belt. . . . .	14.5	4.8	0	4.8
Utility grade chain sizer . . . . .	15.5	3.0	0	3.0
Automatic box filler:				
Lot 1 . . . . .	15.5	2.1	0	2.1
Lot 2 . . . . .	14.5	4.7	.2	4.9
Lot 3 . . . . .	9.5	5.1	1.3	6.4

1/ After apples held at room temperature for 24 hours.

2/ Pressure test not taken, but fruit was soft, probably 9-10 pounds.

One lot of fruit testing 14 pounds, and another testing 17 pounds were used to test the table. With apples testing 14 pounds bruising amounted to only 0.9 percent, and it was all slight. Apples testing 17 pounds showed no bruising at all.



Singulator and sizer.--These two components were tested together. Retarders of 1/4-inch sponge rubber slowed apples as they moved from the spreader belt onto the singulator, and the same material was used to pad dividers under the sizing cups. Bruise-free apples were placed down on the spreader belt which delivered them to the singulator, from which they dropped into sizing cups. Apples dropped through the cups and were recovered from take-away belts as they came from under the sizer. A bruise-free lot of fruit with a pressure test of 14.5 pounds was used in the test. Bruising, all slight, occurred on 1 percent of the apples.

Return-flow belt.--The number of revolutions apples make on a return-flow belt directly influences the amount of bruising that will occur. Two separate tests were conducted, with power shunts used in both cases. The inside belt traveled at 23.5 feet per minute, and the outside belt at 20 feet per minute. One lot of relatively soft fruit was left on the belt for 5 minutes, where the apples averaged 5 revolutions. Bruising amounted to only 0.8 percent. The second lot was left 10 minutes, and the apples averaged 20 revolutions. Three percent of these apples, testing at 10 pounds, were bruised. With both lots the degree of bruising was slight.

Utility disposal belt.--Fruit removed from the sorting table as U. S. Utility grade was released onto a conveyor belt located over the center section of the table. Fruit traveled 28 feet per minute to the end of this conveyor where it dropped 2 inches onto a declining belt conveyor. This conveyor carried the apples to a third and horizontal conveyor, which carried them to a stationary metal shunt. This system was shown in figure 6. A series of retarding drapes installed along the declining portion of the system prevented apples from rolling too fast, and striking the metal shunt.

To test this equipment, bruise-free apples with a firmness of 14.5 pounds were used. They were set down on the conveyor over the sorting table, and transferred to the declining belt conveyor, which carried them down and transferred the fruit to the horizontal belt conveyor. At this point they were recovered and set aside. After 24 hours, 4.8 percent of the apples showed bruising, which was all slight.

Chain sizers.--Two chain sizers were installed as a part of the utility-grade handling system. Running apples over the chain sizers added some bruises to the fruit, but it was desirable to divide utility apples according to size. Test fruit, with a firmness of 15.5 pounds, was introduced immediately before the chain sizer, and recovered after it had dropped through onto the take-away belt. Bruising, all slight, was found on 3 percent of the apples tested.

Automatic box fillers.--To test this box filler for bruising, apples were placed on the take-away belt under the chain sizer, from which they were delivered into the boxes. When a box was full, it was automatically ejected, a new box fell into position, and the process continued until all test apples were used. Filled boxes were recovered from the accumulator conveyor, so that the test included all elements associated with automatic box filling.

Bruise testing was performed with three lots of bruise-free apples. One lot consisted of relatively soft apples, averaging only 9.5 pounds by pressure test. Even with such soft fruit, bruising was found on only 6.4 percent of the apples tested. Slight bruising totaled 5.1 percent, and 1.3 percent of this fruit was bruised moderately. No bruising was found in 93.6 percent of the apples.

The second lot tested had a firmness of 14.5 pounds. Bruising amounted to 4.9 percent, of which 4.7 percent was slight, and 0.2 percent moderate.

Relatively firm fruit at 15.5 pounds by pressure test showed only 2.1 percent of the apples to be bruised, and this bruising was all slight.

Complete line for U. S. Extra-Fancy and U. S. Fancy grade apples.--Bruise-free fruit was run over the entire line in two different tests. Beginning with the dumper, apples moved across the leaf eliminator, over the sorting table, into the singulator and sizer, and out onto distributor belts and the return-flow belt. They were left on the return-flow belt for 2 minutes, then recovered and set aside to be examined after 24 hours at room temperature. Lot No. 1 had an average firmness of 17 pounds, and after 24 hours 1.4 percent of the apples were bruised. Lot No. 2 tested 14.5 pounds, and showed 2.3 percent bruising. In both cases, the bruises were all slight.

### Conclusions

Bruise testing was done with fruit that had been in controlled-atmosphere storage for 6 months, as well as with fresh-harvested fruit. Apples used in the tests had firmness indices that ranged from 9 to 17 pounds, permitting the effect of firmness (or softness) to be studied.

Importance of fruit firmness at the time of handling is illustrated by the results of tests conducted on the same component of the line, but with fruit of different firmness. In every case, the softer the fruit the more it was bruised.

The dumper and utility grade disposal belt caused the most bruising, and the sorting table the least. Bruising on the return-flow belt was proportional to the length of time apples were on the belt and the number of revolutions they made. Large fruit bruised more easily than small fruit. All this suggests that apples should not be left on the return-flow belt any longer than necessary--particularly the large apples. It would probably be better to stop the line occasionally and clean off the belt rather than leave fruit rotating on the return-flow belt.

The automatic box fillers had a remarkably low bruise count, which shows that even tender apples can be jumble-packed mechanically without excessive bruising.



## Sorting with the Experimental Line

The table on which apples were sorted was of a new design (fig. 3). It looked much like the well-known wooden-roller type table but in performance was quite different. The rollers were aluminum, 2-3/8 inches in diameter, and spaced 3 inches on center. Unique features of this sorting table were: (1) Independently controlled rate of translation, (2) independently controlled rate and direction of rotation, (3) table surface divided into lanes, (4) cull disposal chutes located at side of table--one for each sorter, and (5) brusher located at discharge end of table, so that apples were sorted before brushing.

During the testing period rollers traveled at 30 feet per minute, and rotated in a reverse direction at 94 revolutions per minute. By rotating the rollers in a reverse direction, apples were caused to roll in a forward direction. It had been established in other research that objects are easier to sort when they rotate forward. 1/

At a roller rotation rate of 94 r.p.m. an apple measuring 2-3/4 inches in diameter would rotate 8 times while in a sorter's field of vision. Smaller apples would rotate more times, and larger apples fewer. This rate of rotation offered ample opportunity for a sorter to detect a defect on an apple--if the defect were on a visible part of the apple's surface. After detecting and removing a defective apple, the sorter then had to decide if it were utility or cull grade, and dispose of the apple accordingly.

Tests were conducted to determine whether the complete sorting job could be performed at the sorting table, so that packers would not have to re-inspect the apples before packing them. If this could be done, productivity of the packers would be more than doubled. But for such a sorting procedure to be successful, no more off-grade apples could go into packed fruit than did when each apple was individually reinspected by its packer.

Test samples were taken of fruit (1) at the dumper, (2) after it had been passed by the sorters, (3) in cartons of packed combination U. S. Extra-Fancy and U. S. Fancy apples, and (4) in boxes of jumble-packed utility fruit. By sampling at each of these points, it was possible to evaluate the effectiveness of the sorting performed at both the sorting table and the packing stations.

### Sorting at the Sorting Table

In this operation, sorters removed some two-thirds of the utilities, and virtually all of the culls. The actual percentages depended on the number of sorters, dumping rate, and percent of lower-grade apples in the orchard-run fruit. In addition to removing the lower grade apples, sorters also separated culls and utilities, so that these two grades could be boxed separately.

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1/ Malcolm, D. G., and DeGarmo, E. P. Visual Inspection of Products for Surface Characteristics in Grading Operations. U. S. Dept. Agr. Mktg. Res. Rpt. 45. June 1953.

Results of sorting with four and six sorters are presented in table 6. Dumping rates were 167 and 160 boxes per hour. Utility and cull grade apples together were 22.9 percent of the first lot, and 25 percent of the second. In this test, lanes were not used.

Table 6.--Utility grade fruit passed as U. S. Fancy by 4 and 6 sorters, when lanes were not used

Number of sorters	Dumping rate	Utilities and culls in orchard-run fruit	Utilities left in run-off fruit after sorting
	<u>Boxes per hour</u>	<u>Percent</u>	<u>Percent</u>
4 . . . . .	167	22.9	10.0
6 . . . . .	160	25.0	6.7

With four sorters, only 56.3 percent of the utility grade apples in the orchard-run fruit were removed by sorters, which left 10 percent of the run-off fruit below grade. With six sorters, 73.2 percent of the utilities were sorted out so that only 6.7 percent of the run-off fruit consisted of utility grade apples. By adding two sorters to the sorting crew, below-grade apples passed by the sorters was reduced significantly. However, the dumping rate and percent of lower-grade fruit could not be held constant during the test period, so that only general comparisons are possible.

Lanes were formed with lengths of cord, which divided each side into two 6-inch or three 4-inch sections. With each sorter observing only those apples in her lane, 18 percent fewer utility grade apples were passed as U. S. Fancy grade fruit. In addition to improving the quality of sorting, this method was preferred by the sorters.

#### Sorting at the Packing Station

When only four sorters were working, packers inspected all apples individually for size and quality before placing them in cells. This practice limited the number of cartons a packer could cell pack, and precluded the use of mechanical equipment in the packing operation; but it was employed to assure that a minimum of undergrade fruit would get into the cell packed cartons. "Second sorting" was studied to determine how effective it was in reducing the number of off-grade apples packed out. With this method, a packer picked an apple up from the return-flow belt, examined it, and then placed the apple in a cell. The data revealed that the packer's inspection of each apple before packing it gave no assurance that the cell-packed carton would be free of utility grade fruit. Even when the packer inspected each apple, the pack contained 6.9 percent utility grade fruit. This compares with 6.7 percent utilities in the packed fruit when six sorters were used and the packer did not reinspect the fruit. Essentially the same results were achieved with the jumble-boxing of utility grade fruit by automatic box fillers. With six sorters



no more cull apples entered the utility boxes than when there were four sorters and utilities were boxed by hand.

### Sizing with the Experimental Line

Each apple was sized according to its greatest diameter. This operation was performed by the dimension sizer (fig. 5), which consisted of a singulator, sizing cups, and take-away conveyors.

#### How Apples Were Sized

As apples rolled off the sorting table they were distributed on the spreader belt which carried them to the singulator. The purpose of the singulator was to arrange apples to enter the sizer cups with their stems up, and with only one apple to a cup. In practice, apples settled in the cups in a completely random manner, but the singulator did do a good job of spacing fruit. After dropping off the end of the spirals, an apple would fall into a pocket between rubber paddles of a paddlewheel. As this device rotated it delivered the apple into a plastic sizing cup.

As cups moved forward, their front and back hemispheres gradually separated until the apple fell through onto a take-away conveyor. The point at which the apple dropped through determined its size classification. The smallest size dropped out first; the largest size last. Six take-away belts delivered apples to distributor belts, which in turn delivered apples to the return-flow belt. Take-away belts underneath the sizers were separated from adjoining belts by inverted V-dividers padded with sponge rubber.

#### Accuracy of the Sizer

Results of any sizing test will reflect the precision with which each sizer unit was adjusted. Since there were no predetermined settings, adjustment was largely by judgment. There was no way of knowing the state of adjustment at the time samples were drawn, and the data should not be considered as conclusive. Samples were drawn from each of the six take-away belts. In the reference, the first belt refers to the one for the smallest size apples, and the 6th belt to the one for the largest size. The data are presented in table 7.

A range in apple diameter of 1/2 inch was found with each belt, but an average of 79 percent of the apples from each belt were within a 1/4-inch range. The first belt had the greatest range, with apples from 2-1/4 to 2-7/8 inches in diameter. Within the diameter range of 2-5/8 to 3-1/8 inches were 73 percent of all the apples. They appeared in about equal numbers on the 2nd, 3rd, 4th, and 5th belts.

The degree to which precision sizing is necessary depends on requirements of individual packinghouses. In some the accuracy obtained with a dimension sizer will suffice; in others greater accuracy would be required. Whatever the



case, the sizing data presented here are for information only, since it is possible that other results would occur with different lots of fruit and different settings.

Table 7.--Range of apple sizes from each of 6 sizing units of a dimension type sizer

Diameter of apples in inches	Take-away belt <sup>1/</sup>						Total apples
	1st	2nd	3rd	4th	5th	6th	
			<u>Number of apples</u>				<u>Number</u>
2-1/4 - 2-3/8....	1						1
2-3/8 - 2-1/2....	19						19
2-1/2 - 2-5/8....	38	9					47
2-5/8 - 2-3/4....	31	45	10				86
2-3/4 - 2-7/8....	11	44	42	21	2		120
2-7/8 - 3.....		2	39	37	39		117
3 - 3-1/8.....			5	34	44	30	113
3-1/8 - 3-1/4....				8	15	48	71
3-1/4 - 3-3/8....						20	20
3-3/8 - 3-1/2....						2	2
Total.....	100	100	96	100	100	100	596

<sup>1/</sup> Take-away belt from which apple was removed. First belt refers to one for smallest fruit; 6th belt to one for largest fruit.





